Blended Cactus Dye-Based Solar Cell

Study done by Camryn Goldsmith

Introduction

Solar panels are a technology that allows people to make clean energy. Their made up of multiple solar cells, and each cell is made of two semiconductors being stuck together. These semiconductors are treated in some way to make one side positively charged and the other negatively charged (Dhar). Most of these panels are made using silicon, but there are other types that use perovskite crystals or dye and titanium dioxide. Cells using dye are called dye-sensitized cells. Dye-sensitized cells work by having the dye absorb sunlight and create electricity by absorbed photons knocking electrons out of place (Lisensky). Dye-sensitized cells, however, have the issue of having short lifespans and share the issue of being too inefficient just like other types of solar cells.

Criteria & Constraints

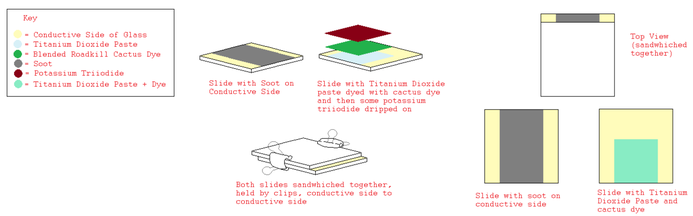
I would like the cell to be able to produce at least 200 mV under full sunlight. As for constraints, the cell will be only be 1 inch by 1 inch.

Design

The original projected design of the solar cell was using the mucilage of a fermented prickly pear cactus as a dye. This was because of a study that noted that the mucilage of one of these cactuses had high photosensitive properties, meaning it could be a good choice for the photoreactive layer of a dye sensitized cell (Olivares-Pérez).. This plan, however, was scrapped because of the foul odor the fermented cactus produced. I could not carry on using it, since it would most likely be disruptive to the others using the same lab space.

The design that was actually used in tests used blended cactus rather than a fermented cactus' mucilage. One trial used a cactus that was freshly cut only a few hours before being applied and kept cold in an airtight container before use. The second trial was done using a cactus that had been left in an airtight, room-temperature container for a week before use.

The cactus dye reacts to the photons from sunlight, knocking electrons in the dye into the titanium dioxide layer of the cell. The electrons move through a wire to get back to the dye, creating an electric current.



Above is a diagram of the solar cell

Methods

First the cactus had to be prepared, which was done by plucking off a few cladodes of a living cactus and cutting them into 1" by 1" squares. They were then placed inside an airtight container. Then, two slides of FTO glass were cleaned and one was covered in a square of titanium dioxide paste and then baked. The cactus squares were then blended and the resulting liquid was poured to cover the FTO glass with titanium dioxide. After the titanium dioxide absorbed the cactus, any excess was cleaned off. The other FTO glass was passed over a candle to build up a layer of soot. Both glasses were then sandwiched together with a few drops of potassium triiodide between them. Binder clips kept them together.

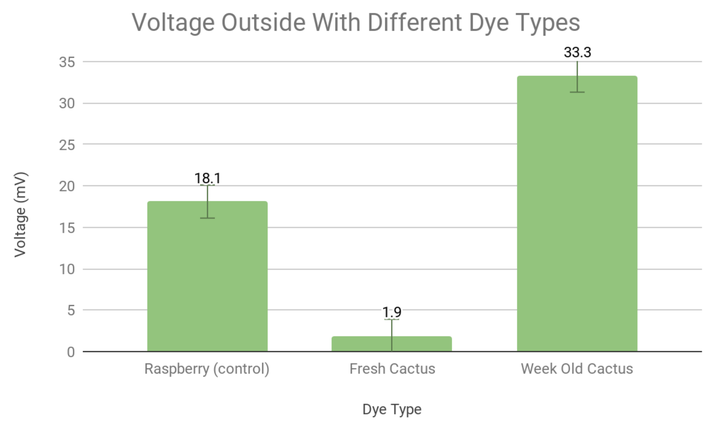
Data

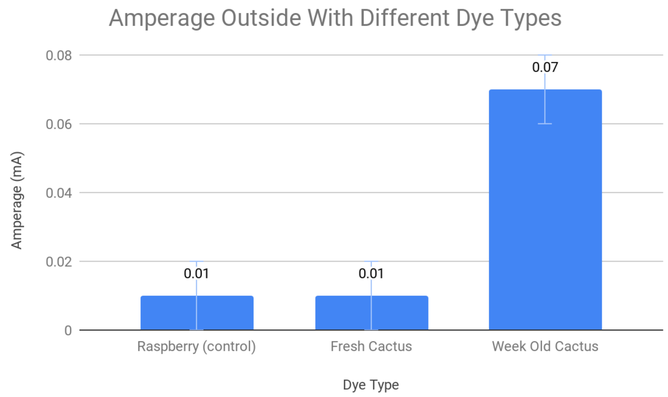
Cell Type	Indoor Voltage (mV)	Indoor Amperage (mA)	Outside Voltage (mV)	Outside Amperage (mA)	Average Volt	Average Amp
Raspberry (control)	171.6	0.02	18.1	0.01	94.85	0.015
Fresh Cactus	4.7	0.08	1.9	0.01	3.3	0.045
Week Old Cactus	222.2	0.1	33.3	0.07	127.75	0.085
Both Cactus (Average)	113.45	0.09	17.6	0.04		

Cell Type	Average Voltage (mV)	Average Amperage (mA)	Voltage Range (mV)	Amperage Range (mA)
Raspberry	94.85	0.015	153.5	0.01
Fresh Cactus	3.3	0.045	2.8	0.07
Week Old Cactus	127.75	0.085	188.9	0.03

The raspberry data is from a previous experiment using dye-sensitized cells. The raspberry data is used as a control on here to show how the cactus cells compared to a different type of dye-sensitized cell.

Also, something to note is that the cells did not respond appropriately when placed under shade, so they may not be photoreactive.





Conclusion

Based upon the data, it seems that the week old cactus was the best and most effective of the solar cells. It had a consistently higher voltage and amperage indoors and outdoors compared to the both the fresh cactus and control of raspberry juice. That said, it technically didn't fulfill my goal. Outside it only produced 33.3 mV, though it was capable of producing at least 200 mV inside. Meanwhile the cell using fresh cactus was only able to produce 4.7 mV indoors and 1.9 outdoors. The results of this data makes me believe that the original idea of a cactus being left to ferment for more than a week would produce the best results.

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